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Department of the Interior
US Geological Survey
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August 25, 2005

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington DC 20555

Gentlemen:

The U.S. Geological Survey is herein providing clarification and additional supporting information in response to your request for additional information (TAC No. MC5120) dated March 10, 2005. This concerns the USGS amendment request to its research reactor facility license (No. R-113, Docket 50-274) to allow the use of aluminum-clad TRIGA fuel in the core.

Sincerely,

Tim DeBey

Tim DeBey
Reactor Supervisor

Please docket
50-274
Thanks

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 8/25/05 Tim DeBey 8/25/05

A020

CLARIFICATION AND ADDITIONAL SUPPORTING INFORMATION FOR THE LICENSE AMENDMENT REQUEST FOR USE OF ALUMINUM-CLAD FUEL AT THE UNITED STATES GEOLOGICAL SURVEY; DOCKET NO. 50-274

1. In our response dated April 8, 2005 we proposed to revise Technical Specification D.3: to limit the measured fuel temperature to 750 °C for B-ring measurements and 667 °C for C-ring measurements. However, our analysis only supported actual peak fuel temperatures at those levels, not measured fuel temperatures. The measured fuel temperature limits need to be 15 degrees lower to allow for possible inaccuracies in the measurement instrumentation. As a result, the proposed change in Technical Specification D.3 needs to be for measured fuel temperatures of 735°C and 652°C, respectively for the B and C rings. The revised proposed change is given below. We propose to not specify a limit on the aluminum-clad fuel in the F and G rings for two reasons: (1) the limits being imposed upon the B and C-ring fuel temperatures will inherently protect the F and G ring fuel elements from exceeding 500°C, and (2) no instrumented aluminum-clad fuel elements are available to provide the associated measurements. The necessary calculations to support the safety of the aluminum-clad fuel elements in the F and G rings have been provided in the documents supporting the license amendment request.

Current wording:

D.3. Fuel temperatures near the core midplane in either the B or C ring of elements shall be continuously recorded during the pulse mode of operation using a standard thermocouple fuel element. The thermocouple element shall be of 12 wt% uranium loading if any 12 wt% loaded elements exist in the core. The reactor shall not be operated in a manner which would cause the measured fuel temperature to exceed 800°C.

Proposed wording:

D.3. Fuel temperatures near the core midplane in either the B or C ring of elements shall be continuously recorded during the pulse mode of operation using a standard thermocouple fuel element. The thermocouple element shall be of 12 wt% uranium loading if any 12 wt% loaded elements exist in the core. The reactor shall not be operated in a manner which would cause the measured fuel temperature to exceed 735°C in a stainless steel clad element in the B ring or 652°C in a stainless steel clad element in the C ring.

2. In order to help summarize and clarify calculated fuel temperature data under various operating conditions, we have prepared the following table of data. The table includes calculated peak fuel temperatures in the USGS reactor under the following conditions:

a. normal full power (1MW) operation with the current core condition of 125 fuel elements and typical water temperature.

b. overpower operation at 1.1 MW (maximum high power scram setting) with the current core condition of 125 fuel elements and typical water temperature.

c. overpower operation at 1.1 MW with the current core condition of 125 fuel elements and water temperature at the maximum allowed (60C).
d. overpower operation to create a peak temperature of 750C in a B-ring fuel element (approximately 2.1 MW) with maximum water temperature.
e. normal full power operation (1 MW) with the minimum core loading (100 fuel elements) and typical water temperature.
f. overpower operation at 1.1 MW with the minimum core loading and typical water temperature.
g. overpower operation at 1.1 MW with the minimum core loading and maximum water temperature.
h. a maximum allowed pulse ($3.00) with the minimum core loading and maximum water temperature.
i. overpower operation to create a peak temperature of 750C in a B-ring fuel element (approximately 1.2 MW) with maximum water temperature.

The data for 125 elements in the core are based on empirical values measured during 1 MW operation and then scaled appropriately for the changed conditions. The scaling was performed by conservatively assuming that the heat transferred from the fuel elements is by free convection (i.e., ignoring radiation heat transfer) so that the rate of heat transferred (i.e., power transferred) to the tank water is directly proportional to the difference in temperature (ΔT between the fuel element's temperature and the cooling water's temperature. ($Q = hA\ (\Delta T)$ where Q is the heat transfer rate, h is the heat transfer coefficient, A is the surface area, and ΔT is the temperature difference.

The data for 100 elements in the core are based on element power calculations performed using the MCNP (monte carlo) computer code for a 100 element configuration of the GSTR core. These data were examined and reviewed by the NRC for our license amendment number 8, dated March 16, 1998. The data are appended to this letter as Attachment 1. The scaling of core conditions was performed in the same manner as it was for the 125-element core, as described in the preceding paragraph. Another data analysis that we performed to further aid in our understanding of the fuel temperatures resulted in the graph shown as Attachment 2. This graph provides a correlation between fuel element power production in kW and the peak delta T (°C) between the fuel temperature and the pool water temperature. The graph was developed by fitting a line to empirical fuel temperature measurements vs the respective MCNP power calculations. Since the MCNP output is kW produced in each fuel element, the graph can then be used to find the peak fuel element temperature by reading the delta T and adding the pool water temperature. For example, an element producing 5 kW with a pool water temperature of 25C would have a peak fuel temperature of 130.9 + 25 =155.9 °C.

A core of 100 elements causes more power peaking in the center of the core and lower power production in the outer elements because of the loss of fuel and graphite that was present in the 25 fuel elements that were eliminated. The net result is that the G-ring element temperatures are lower in the 100-element core when compared to a 125-element core. However, the F-ring element temperatures are higher in the 100-element core when compared to a 125-element core.

The 100-element core also reaches the 750°C limit of the B-ring temperatures at a much lower total power than in the 125-element core. This makes the F and G-ring temperatures lower for the smaller core under these conditions than it is for the larger 125-element core.

We believe the table below provides a concise summary of all operational conditions that could cause high temperatures in the fuel elements. In all cases, the fuel temperatures of the F and G ring elements stay well below 500°C.

Description of Operation		**Calculated peak fuel temp (°C)**			
Core configuration and power level	Coolant temperature	B-ring	C-ring	F-ring	G-ring
125 elements, 1 MW SS	25C	348	309	206	176
125 elements, 1.1 MW SS	25C	380	337	224	191
125 elements, 1.1 MW SS	60C	415	373	259	226
125 elements, B-ring at 750C (note: the power level required is ~ 2.1 MW)	60C	750	667	447	383
100 elements, 1 MW SS	25C	604	558	224	159
100 elements, 1.1 MW SS	25C	662	612	244	173
100 elements, 1.1 MW SS	60C	702	652	284	213
100 elements, $3 pulse	60C	500	442	296	252
100 elements, B-ring at 750C (note: the power level required is ~ 1.2 MW)	60C	750	695	299	224

Summary of other proposed technical specification changes:

Section D *Reactor Core*

Current wording:

6. Each standard fuel element shall be checked for transverse bend and longitudinal elongation after the first 100 pulses of any magnitude and after every 500 pulses or every 60 months, whichever comes first.

The limit of transverse bend shall be 1/16-inch over the total length of the clad portion of the element (excluding end fittings). The limit on longitudinal elongation shall be 1/10 inch. The reactor shall not be operated in the pulse mode with elements installed which have been found to exceed these limits.

Any element which exhibits a clad break as indicated by a measurable release of fission products shall be located and removed from service before continuation of routine operation.

Proposed wording:

6. Each standard fuel element shall be checked for transverse bend and longitudinal elongation after the first 100 pulses of any magnitude and after every 500 pulses or every 60 months, whichever comes first.

During the first 5 years of aluminum-clad fuel usage, annual fuel transverse bend and longitudinal elongation measurements will be made on 20% of the aluminum-clad fuel elements that have been in the core at any time during that year. The measurement schedule will be controlled such that different fuel elements are measured each year for this initial 5-year period. After this initial 5 years of aluminum-clad fuel usage, if no generic problems have been detected, the inspection schedule will revert back to the standard fuel 60-month schedule.

The limit of transverse bend shall be 1/16-inch over the total length of the clad portion of the element (excluding end fittings). The limit on longitudinal elongation shall be 1/10 inch for stainless steel clad elements and ½-inch for aluminum clad elements. The reactor shall not be operated in the pulse mode with elements installed which have been found to exceed these limits.

Any element which exhibits a clad break as indicated by a measurable release of fission products shall be located and removed from service before continuation of routine operation. Fuel elements that have been removed from service do not need to be checked for transverse bend or longitudinal elongation.

Section D. Reactor Core

Current wording:

7. The power produced by each fuel element while operating at the rated full power shall be calculated if the reactor is to be operated at greater than 100 kW with less than 100 fuel elements in the core. Recalculations shall be performed:

a) at 6 ± 1 month intervals, or
b) whenever a core loading change occurs.

Power per element calculations are not required at any time that the core contains at least 100 fuel elements or if reactor power is limited to 100 kW. If the calculations show that any fuel element would produce more than 22 kW, the reactor shall not be operated with that core configuration.

Proposed wording:

7. *Observance of the license and technical specification limits for the GSTR will limit the thermal power produced by any single fuel element to less than 22 kW if the reactor has at least 100 fuel elements in the core. Therefore the reactor must have at least 100 fuel elements in the core if it is to be operated above 100 kW. Operations with less than 100 fuel elements in the core will be restricted to a maximum thermal power of 100 kW.*

Proposed new (additional) technical specifications:

Section C. <u>Reactor Pool and Bridge</u>

<u>Proposed additional specification wording:</u>

3. The control console shall have an audible and visual water level alarm that will actuate when the reactor tank water level is between 12 and 24 inches below the top lip of the tank. This water level alarm shall be functionally tested monthly, not to exceed 45 days between tests. This item is not applicable if the reactor is completely defueled and the pool level is below the water treatment system intake.

Section C. <u>Reactor Pool and Bridge</u>

<u>Proposed additional specification wording:</u>

4. The pool water shall be sampled for pH at quarterly intervals, not to exceed 4 months. The pH level shall be within the range of 4.5 to 7.5 for continued operation. This item is not applicable if the reactor is completely defueled and the pool level is below the water treatment system intake.

Attachment 1

MCNP ANALYSIS of GSTR CORE (100 elements)

Eight 12 w/o in B,C rings 100 elements

GRID DESCRIPTION	Serial No.	Power factor	Error	Max power (kW)
fuel rod 12 w/o #b1	7832	2.11	0.01	21.3110
fuel rod #b2	9304	1.73	0.01	17.4730
fuel rod 12 w/o #b3	7864	2.12	0.01	21.4120
fuel rod 12 w/o #b4	7865	2.15	0.01	21.7150
fuel rod #b5	3701	1.59	0.01	16.0590
fuel rod 12 w/o #b6	7867	2.06	0.01	20.8060
fuel rod #c1	9531	1.27	0.011	12.8397
fuel rod #c11	9842	1.33	0.011	13.4463
fuel rod #c12 12 w/o	1238	1.84	0.01	18.5840
fuel rod #c2 12 w/o	1240	1.92	0.01	19.3920
fuel rod #c3	7932	1.38	0.01	13.9380
FFCR in #c4	10252	1.58	0.011	15.9738
fuel rod #c5	9532	1.38	0.01	13.9380
fuel rod 12 w/o #c6	7869	1.98	0.01	19.9980
fuel rod #c7	9533	1.34	0.01	13.5340
fuel rod #c8 12 w/o	1235	1.9	0.01	19.1900
fuel rod #c9	3007	1.39	0.01	14.0390
FFCR in #d1	5765	0.96	0.012	9.7152
FFCR in #d10	5980	1.39	0.011	14.0529
fuel rod #d11	7200	1.25	0.011	12.6375
fuel rod #d12	7927	1.17	0.011	11.8287
fuel rod #d13	5007	1.16	0.011	11.7276
fuel rod #d14	3321	1.23	0.011	12.4353
fuel rod #d15	7933	1.11	0.011	11.2221
fuel rod #d16	4096	1.14	0.011	11.5254
fuel rod #d17	5030	1.14	0.012	11.5368
fuel rod #d18	2374	1.13	0.011	11.4243
fuel rod #d2	7928	1.18	0.011	11.9298
fuel rod #d3	7929	1.16	0.011	11.7276
fuel rod #d4	3250	1.19	0.011	12.0309
fuel rod #d5	3695	1.33	0.011	13.4463
fuel rod #d6	7931	1.21	0.011	12.2331
fuel rod #d7	7926	1.18	0.011	11.9298
fuel rod #d8	3134	1.23	0.011	12.4353
fuel rod #d9	7930	1.25	0.011	12.6375
fuel rod #e1	4128	0.96	0.013	9.7248
fuel rod #e10	3017	1.02	0.012	10.3224
fuel rod #e11	3863	1.1	0.012	11.1320
fuel rod #e12	3660	1.07	0.012	10.8264
fuel rod #e13	3116	1.03	0.012	10.4236
fuel rod #e14	2445	1	0.012	10.1200
fuel rod #e15	5952	1.02	0.012	10.3224
fuel rod #e16	3022	0.97	0.013	9.8261
fuel rod #e17	3697	0.99	0.012	10.0188
fuel rod #e18	6587	1.02	0.012	10.3224
fuel rod #e19	5751	0.99	0.012	10.0188
fuel rod #e2	6843	0.89	0.013	9.0157
fuel rod #e20	5957	0.92	0.013	9.3196
fuel rod #e21	5699	0.79	0.013	8.0027
fuel rod #e22	5704	0.82	0.013	8.3066
fuel rod #e23	5705	0.81	0.013	8.2053

Eight 12 w/o in B,C rings 100 elements

GRID DESCRIPTION	Serial No.	Power factor	Error	Max power (kW)
fuel rod #e24	3361	0.93	0.013	9.4209
fuel rod #e3	6839	0.97	0.012	9.8164
fuel rod #e4	5761	0.96	0.012	9.7152
fuel rod #e5	5755	1	0.012	10.1200
fuel rod #e6	5754	1.03	0.012	10.4236
fuel rod #e7	6840	1.07	0.012	10.8284
fuel rod #e8	3857	1.03	0.012	10.4236
fuel rod #e9	5013	1.03	0.012	10.4236
fuel rod #f1	5726	0.6	0.015	6.0900
fuel rod #f10	5759	0.74	0.014	7.5036
fuel rod #f11	5748	0.67	0.014	6.7938
fuel rod #f12	5728	0.75	0.014	7.6050
fuel rod #f13	5735	0.73	0.014	7.4022
fuel rod #f14	5744	0.74	0.014	7.5036
fuel rod #f15	5737	0.75	0.014	7.6050
fuel rod #f16	5716	0.7	0.014	7.0980
fuel rod #f17	5730	0.73	0.014	7.4022
fuel rod #f18	5743	0.7	0.014	7.0980
fuel rod #f19	5740	0.69	0.014	6.9966
fuel rod #f2	5707	0.7	0.014	7.0980
fuel rod #f20	5706	0.72	0.014	7.3008
fuel rod #f21	5731	0.63	0.015	6.3945
fuel rod #f22	5732	0.69	0.014	6.9966
fuel rod #f23	5729	0.68	0.015	6.9020
fuel rod #f24	5753	0.68	0.015	6.9020
fuel rod #f25	5745	0.68	0.014	6.8952
fuel rod #f26	5725	0.62	0.015	6.2930
fuel rod #f27	5747	0.65	0.015	6.5975
fuel rod #f28	5727	0.66	0.015	6.6990
fuel rod #f29	5741	0.65	0.015	6.5975
fuel rod #f3	5717	0.67	0.015	6.8005
fuel rod #f30	5756	0.65	0.015	6.5975
fuel rod #f4	5719	0.69	0.015	7.0035
fuel rod #f5	5734	0.71	0.014	7.1994
fuel rod #f6	5760	0.68	0.014	6.8952
fuel rod #f7	5739	0.73	0.014	7.4022
fuel rod #f8	5708	0.74	0.014	7.5036
fuel rod #f9	5750	0.73	0.014	7.4022
fuel rod #g1	9472	0.49	0.017	4.9633
fuel rod #g10	5720	0.5	0.016	5.0800
water #g11				0.0000
water #g12				0.0000
fuel rod #g13	5736	0.51	0.016	5.1816
water #g14				0.0000
water #g15				0.0000
fuel rod #g16	5701	0.51	0.016	5.1816
water #g17				0.0000
water #g18				0.0000
fuel rod #g19	5682	0.51	0.016	5.1816
water #g2				0.0000
water #g20				0.0000

Attachment 1

Eight 12 w/o in B,C rings 100 elements

GRID DESCRIPTION	Serial No.	Power factor	Error	Max power (kW)
water #g21				0.0000
fuel rod #g22	5676	0.5	0.017	5.0850
water #g23				0.0000
water #g24				0.0000
fuel rod #g25	5758	0.49	0.017	4.9833
water #g26				0.0000
water #g27				0.0000
fuel rod #g28	5678	0.45	0.017	4.5765
water #g29				0.0000
water #g3				0 0000
water #g30				0.0000
fuel rod #g31	5686	0.44	0.017	4.4748
water #g32				0.0000
water #g33				0.0000
water #g34				0.0000
water #g35				0.0000
water #g36				0 0000
fuel rod #g4	5683	0.47	0.017	4.7799
water #g5				0.0000
water #g6				0.0000
fuel rod #g7	5762	0.48	0.017	4.8816
water #g8				0.0000
water #g9				0.0000

Attachment 2